CLAIMS

1. A Supervisory Command and Data Acquisition (SCADA) system for managing a wind farm having an array of wind turbines for electric power generation and one or more meteorological sites, each wind turbine being located at a turbine site and electrically connected for power transmission to a substation located at a substation site, the system comprising:

a turbine processing unit (TPU) located at each wind turbine, the TPU being a processing element functioning as the SCADA element for that turbine, the TPU being configured to collect data from the turbine and turbine site, to provide an interface to control the turbine, and to communicate with other parts of the system from the turbine site, the TPU being further configured to store locally at the TPU data collected from the turbine and turbine site;

a substation processing unit (SPU) located at the substation operating as the interface for the system to the substation, the SPU being a processing element functioning as the SCADA element for that substation, the SPU being configured to collect data from the substation, to communicate with other parts of the system, and to store locally at the SPU data collected from the substation;

a meteorological processing unit (MPU) located at each meteorological site functioning as the SCADA element for the site, the MPU being configured to collect meteorological data from sensors on and at a meteorology tower, to communicate with other parts of the system, and to store locally at the MPU data collected from sensors on and at a meteorology tower;

a data communication network;

a server coupled to communicate over the network with the wind turbines, the substation, and the one or more meteorological sites, the server being configured to receive data from them through their respective the SCADA elements (TPU, MPU, or SPU) and to provide signals to control the wind turbines and substation through their respective SCADA elements, the server being further configured to store data received from the wind turbines, meteorological sites, and substation at regular intervals and to perform database management on the received data; and

a user interface through which authorized users can exercise command and control functions for the wind farm.

2. The system of claim 1, wherein:

the user interface is a graphical user interface (GUI) that can be accessed locally through a direct connection to the network or a direct connection to an element of the system.

3. The system of claim 2, wherein:

the user interface provides views to each SCADA element to allow users access to real time data and subsystem controls.

4. The system of claim 1, wherein:

the user interface is a graphical user interface (GUI) that can be accessed remotely over a wide area network such as the Internet.

5. The system of claim 3, wherein:

the user interface provides views to each SCADA element to allow users access to real time data and subsystem controls.

6. The system of claim 1, further comprising:

one or more control workstations, a workstation being a client computer of any kind, the one or more control workstations being configured to process data from the server and to provide real-time monitoring and control of the wind power system.

7. The system of claim 1, wherein:

one or more of the TPUs are configured to provide a connection for a portable device to allow a user of the portable device to communicate through the user interface with other components of the system.

8. The system of claim 1, wherein:

each TPU is configured to store data locally for a time sufficient to bridge any anticipated unavailability of the server.

9. The system of claim 1, wherein:

each TPU is configured to collect data including wind turbine controller state, wind speed, energy levels, and alarms; and

each TPU is configured to interact with the system through an Ethernet port and with workers working at the TPU through local ports.

10. The system of claim 1, wherein:

each TPU is built on a general purpose computer platform running a general purpose operating system; and

each TPU is configured to execute a client application providing local data collection and site control.

11. The system of claim 1, wherein:

the wind turbines comprise wind turbines that have turbine controllers that are proprietary to the respective wind turbine manufacturers and the TPU for each such turbine provides a uniform interface to the system from the proprietary turbine controllers.

12. The system of claim 11, wherein:

each TPU and its turbine controller are connected using an optically isolated connection.

13. The system of claim 1, wherein:

each TPU is connected to communicate with the server through an optical fiber.

14. The system of claim 1, wherein:

the SPU is configured to monitor the substation for discrete and analog inputs and the manage outputs set by the system.

15. The system of claim 1, wherein:

at least one meteorological site has a meteorology tower with sensors to monitor horizontal wind speed and direction from at least four levels above the ground, vertical wind speed, temperature, and atmospheric pressure.

16. The system of claim 1, wherein:

each MPU is built on a general purpose computer platform running a general purpose operating system; and

each MPU is configured to execute a client application providing local data collection and site control.

17. The system of claim 1, wherein:

each TPU, MPU, and SPU is configured to store the data collected by the unit over at least 48 hours of operation; and

the server is configured to store the raw data collected over at least two months of operation of the system.

18. The system of claim 1, wherein:

the turbines are grouped into parks.

19. A system for managing a wind farm having an array of wind turbines for electric power generation, the system comprising:

a Supervisory Command and Data Acquisition (SCADA) element at each wind turbine configured to collect data from the turbine;

a SCADA element at each of one or more meteorological sites configured to collect meteorological data; and

a SCADA element at each of one or more substations, the substations being electrically connected with the wind turbines for power transmission;

a server coupled to communicate with the wind turbine, meteorological, and substation SCADA elements, the server being configured to receive and to store data received from the elements at regular intervals and to perform database management on the received data, the server being further configured to gather and maintain detailed current and historical data as to the inputs, operating conditions, and outputs of all turbines of the wind farm at a high degree of time resolution.

20. The system of claim 19, wherein the data gathered at a high degree of time resolution comprises:

data including wind speed and energy production gathered from each wind turbine once a second;

meteorological data gathered from each meteorological site once every 30 seconds; and

substation data including power production each substation.

21. The system of claim 19, wherein the data gathered at a high degree of time resolution comprises:

wind turbine data including power, reactive power, wind speed, energy subtotal, and total energy data gathered from each wind turbine once a second.

22. The system of claim 21, wherein the wind turbine data further comprises:

data for each wind turbine representing generator rotational speed, generator temperature, gearbox temperature, ambient temperature, wind speed, wind direction, real power, reactive power, power factor, phase voltage and phase current for each phase, energy production, and production time.

23. The system of claim 20, wherein the data gathered at a high degree of time resolution further comprises:

data including controller state gathered from each wind turbine;

meteorological data including vertical and horizontal wind speeds, wind direction, temperature, and air pressure gathered from each meteorological site; and

substation data including total active energy out from the substation, total reactive energy out from the substation, total active energy into the substation, and total reactive energy into the substation.

24. The system of claim 19, wherein the wind farm is organized into parks for reporting and management purposes and the data gathered at a high degree of time resolution comprises:

the energy produced by each park.

25. The system of claim 24, wherein the data for each park includes data collected or calculating describing:

the operational status of each turbine in the park;

the total real power produced in the park;

the total reactive power produced in the park; and

the power factor for the park.

26. A system of claim 19, further comprising a configuration database for the wind farm, the configuration database containing information describing a current configuration of systems elements, the configuration information being used during system initialization, the configuration information comprising:

information describing the wind turbine configuration of the wind farm, the information describing all wind turbine SCADA elements in the wind farm.

27. The system of claim 26, the configuration information further comprising:

information describing each wind turbine of the wind farm, including for each such turbine data source information describing how source data from the turbine is to be mapped to fields in a system database.

28. The system of claim 26, wherein:

the information describing each wind turbine further includes for each such turbine a park identifier identifying a park containing the turbine.

29. The system of claim 26, wherein the SCADA element of each wind turbine is a turbine processing unit coupled to a turbine controller, the configuration information further comprising:

a turbine controller identifier for each turbine for determining correct communication protocols and processing algorithms between the coupled turbine controller and turbine processing unit.

30. The system of claim 26, the configuration information further comprising:

information describing each substation of the wind farm, the information including an identifier and a description for substation in the wind farm.

31. The system of claim 26, the configuration information further comprising:

information describing the meteorological sites of the wind farm, including for each site: a site identifier for determining correct communication protocols with the site, and data source information describing how source data from the site is to be mapped to fields in a system database.

32. The system of claim 26, the configuration information further comprising:

information describing the parks of the wind farm, including for each such park an identifier for the park, a description for the park, and information identifying the substations connected to the park and the wind turbines and meteorological sites in the park.

33. The system of claim 19, further comprising:

computer program processes configured to process wind turbine data to report average power production over a time window, expected power production over the time window, and production efficiency over the time window for each wind turbine in the wind farm.

34. The system of claim 19, wherein the wind farm is organized into parks for reporting and management purposes, the system further comprising:

computer program processes configured to process wind turbine data to report average power production over a time window, expected power production over the time window, and production efficiency over the time window for each wind turbine in each park.